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COMPARISON OF AMBIENT AIR MEASUREMENT AND SOURCE MEASUREMENT

Contract CPA 70–40
SwRI Project 21–2811

Prepared for:

Office of Measurement Standardization
Division of Chemistry and Physics
Air Pollution Control Office
Environmental Protection Agency

April, 1971

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16. Abstracts
Many differences exist between methods used for ambient air measurement and source measurement, related to the differences in concentration, temperature and humidity of the sample streams, interferences that affect analytical results, and other factors. The differences in the two types of methods have been substantial, therefore results obtained with these different methods likely are not equivalent. Emissions cannot be related accurately to ambient air measurements, which makes the job of planning and developing standards much more difficult. Emission standards have little meaning unless a method of measurement is specified, and specific methods or general guidelines have usually been published with such standards. The need for a standardization program is outlined.

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SUMMARY AND CONCLUSIONS

This report was prepared to aid in planning a program to standardize methods of source measurement used in air pollution control. Standardization of methods used for ambient air measurement has been in progress for some time, and new requirements established by recent federal legislation make it necessary to provide standard methods for source measurement as well.

Many differences exist between methods used for ambient air measurement and source measurement, related to the differences in concentration, temperature and humidity of the sample streams, interferences that affect analytical results, and other factors. Because of these factors, methods used in the past for ambient air measurement have been substantially different from methods used for source measurement, and therefore results obtained with these different methods likely are not equivalent. This in turn means that various emissions as measured by the available methods cannot be related accurately to ambient air measurements, which makes the job of planning and developing standards much more difficult.

Emission standards have been developed in the past by a number of air pollution control agencies, and will be required in the future as a part of all implementation plans. The method used most frequently in the past has been the Ringelmann chart for controlling emission of black smoke. Other emission standards have also been used to control visible emissions based on equivalent opacity, particulates measured on a weight basis, and sulfur dioxide as measured by a chemical procedure. A few agencies have developed unique emission standards to control specific problems in their jurisdictions; examples include fluoride, beryllium, hydrocarbons, and others.

Most agencies have recognized the fact that emission standards have little meaning unless a method of measurement is specified, and specific methods or general guidelines have usually been published with the standards. Various scientific and engineering societies have also made some effort at standardization of source measurement methods. None of these efforts have included either a detailed laboratory evaluation of available methods or a collaborative test to establish statistical limits of accuracy and precision.

A study of existing regulations emphasizes the need for an extensive program of standardization of source measurement methods. Available

methods should be compared to select the variations best suited for different source measurement applications. Collaborative testing is also needed, but will be difficult because of practical limitations on the number of participants and number of samples that can be accommodated by the sampling facilities that can be provided on any reasonable basis. Further development of new methods is also needed, so that adequate emission standards can be established for many different types of stationary sources. These methods should include both reference methods and techniques suitable for continuous monitoring and process control.

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I. PURPOSE OF MEASUREMENTS

In order to understand the differences between methods used for ambient air measurement and those used for source measurement, it is important to examine the reasons for making any measurement related to air quality. A most important distinction here is the difference in legal requirements. Ambient air measurements are used to evaluate overall air quality within a community, usually over relatively long periods of time. These measurements are useful for planning purposes to set goals, to document progress in reaching those goals, and to identify areas of a community in which additional control measures may be needed. On a shorter time basis, they may also be useful in indicating when certain emergency measures need to be instituted, although most communities have not yet developed or implemented comprehensive emergency plans, and the difficulties involved in such implementation are quite formidable. However, one important point here is that no immediate legal action against an individual source of pollution is likely to occur, based on ambient air measurements alone.

Source measurements present a different picture. Stack sampling, in particular, is performed to measure emission rates over a very short period of time, to determine whether or not that particular source is exceeding some legally established emission rate. With continuous instruments, stack monitoring in some cases is possible on a minute-by-minute basis. In other cases, limitations on available methods of sampling may make it necessary to take several hours to complete a single sample, but the objective is still to determine emission rates over as short a period of time as possible. The results also provide an immediate indication of legal or illegal operation of the source in question, and may lead to demands for changes in the operation of the source or, in the case of disagreement, to legal action.

These differences in legal requirements place a greater requirement on source sampling methods for short-term or single measurement accuracy and reliability. Errors in a single measurement of ambient air quality are of only minor importance when a large number of measurements are averaged, unless a single measurement is high enough to initiate some emergency action. A consistent error in long-term measurements means primarily that planning may be done less efficiently than desired. While this is regrettable, the errors inherent in the process of developing ambient air standards are likely to be greater than the errors of measurement. However, with source sampling methods, any controversy over the error of even a single measurement may lead to legal action under some circumstances.

II. DIFFERENCES IN REQUIREMENTS

In addition to the different legal requirements for measurements, many other differences exist between ambient air measurements and source measurements. Obviously, there are exceptions, but a consideration of the general differences is helpful in understanding some of the problems involved in developing methods for source measurement.

The most obvious difference usually is one of concentration. As a rule, the concentration of any given pollutant in a stack or duct in an industrial plant can usually be several orders of magnitude higher than levels that are tolerable in a community atmosphere. For example, ambient air measurements of sulfur dioxide must be made in the range of 0.01 to perhaps 0.5 ppm; measurement in a stack carrying tail gases from a sulfuric acid plant may frequently show several hundred parts per million, with legally acceptable concentrations in some areas running as high as 2000 ppm.

Temperature and humidity variations also may be greater within a stack or process stream than in the ambient atmosphere. Excluding only infrequent periods in cold climates, ambient air temperatures normally will be in the range of 20 to 100° F. Stack temperatures, on the other hand, may range all the way from below ambient to 1500° F or above. Humidity can vary correspondingly since the absolute humidity required for saturation is temperature-dependent.

Interferences in analysis may also change drastically in going from a source sampling situation to an ambient air problem. Again, to use sulfur dioxide as an example, interference with a chemical method of measurement in a stack may occur due to the presence of several hundred parts per million of nitric oxide. In the atmosphere, however, much of the NO will have been converted to NO_2, while a portion of the SO_2 will disappear by oxidation to SO_3 or reaction with alkaline particulates. Thus, the absolute quantities of the NO and other interfering substances change drastically as well as the ratios of these various substances to the sulfur dioxide being measured. The formation of secondary pollutants in an ambient atmosphere by photochemical reaction and in other ways also introduces other intereferences not originally present in the process gas measured at the source.

For these various reasons, measurements at the source and measurements in the ambient atmosphere may not be related to each other. In other words, a measurement which indicates a pound of SO_2

in a stack may not correspond to an ambient air measurement indicating a pound of SO_2 distributed in a certain volume of the atmosphere. Likewise, a source measurement indicating a pound of SO_2 in the gases from a sulfuric acid plant may be subject to entirely different errors than a measurement indicating a pound of SO_2 in the flue gas from a coal-fired boiler.

One suggestion for reducing the impact of these variations in interfering substances is to use the same method for stack sampling that is used for ambient air measurements, and dilute the stack gas sufficiently to reach the same concentration range. This would allow the use of continuous monitoring instruments and other techniques of measurement commonly used in ambient air sampling for stack measurements. While this suggestion has some merit, differences in interfering substances and the difficulties involved in maintaining an accurate dilution ratio make this something less than a cure-all for all of the problems which exist.

The differences in working conditions for sampling also increase the cost of making measurements and exert a psychological effect on persons involved in such work. Ambient air measurements are usually made at or near ground level. By bringing air into a building through a suitable air inlet, an investigator can work in air-conditioned comfort. In most stack sampling, however, the actual work of sample collection must be conducted by manual methods immediately adjacent to a duct or stack carrying the gases to be emitted. The only suitable sampling points may be located on a stack 100 feet or more above ground level. Construction of access ports, sampling platforms, and other mechanical facilities may require major construction and alteration of facilities, and may only be possible when the entire unit is shut down for routine maintenance. During sampling, much lost time and personal inconvenience occurs due to the necessity for climbing up and down ladders, hauling equipment up and down with a block and tackle, running extension cords for several hundred feet to obtain electrical power, and other similar tasks. This means that workers must be more highly motivated in order to obtain high quality data, and the cost per sample will usually be much higher than the cost of ambient air sampling and analysis. The only partial solution for these problems in the near future is the development of automatic instruments for stack monitoring, which can reduce the amount of work which must be done by manual methods but cannot eliminate such work.

III. EMISSION STANDARDS AND MEASUREMENT METHODS

In order to understand the problems in evaluating source sampling methods, it is helpful to examine the regulations which are now in use and the methods of measurement which are specified. These two must be considered together, since no emission standard has much meaning unless the method of measurement is specified. To do this, a number of air pollution control ordinances and regulations were examined to identify the emission standards and methods of measurement that are now in use. While not complete, this brief survey gives a general summary of the methods now being used throughout the country. These are divided into two categories: (1) those that are in general use in many jurisdictions and (2) those in use in only a few jurisdictions because of special problems or as a result of pioneering efforts by the agencies involved.

The most general emission standard is a limit on black smoke based on evaluation by the well known Ringelmann chart. This standard appears in practically all air pollution control ordinances and regulations that deal with emission standards of any type. For many years, emissions were limited to No. 2 Ringelmann in most jurisdictions, but recently there has been a tendency to impose a No. 1 limitation.

Perhaps the second most used method is the regulation of visible emissions other than black smoke by the concept of equivalent opacity. There are valid scientific objections to this concept, and margins for error in measurement are greater than desired; nevertheless, the concept is a valid one and can be used satisfactorily if inspectors are trained properly. It is also legally acceptable, having been upheld in courts of law up to and including the U. S. Supreme Court.

Another type of emission standard which appears frequently is the imposition of emission limits based on the weight of material emitted. A major limitation here is that the adverse effects of an emission may not be directly related to weight because of differences in particle size, corrosivity, or other characteristics; nevertheless, weight is a convenient unit of measure that has been widely used. Regulations of this type appear to have been developed initially to limit emissions of fly ash and other particulate matter from coal-burning equipment, and more recently weight limitations have been applied to incinerators and other combustion sources as well as process units not involving combustion. Weight limits applicable to combustion sources are expressed in many different ways such as grains per cubic foot, pounds per hour, pounds per thousand pounds of air, etc. Units based on volume of gas discharged

are usually corrected to some standard condition such as 12% CO_2 to compensate for changes in the amount of dilution air which may be present; this correction also avoids circumvention through the deliberate addition of dilution air. The ASME Power Test Codes provide the basic standard methods that have been widely used in measuring the particulate content of stack gases. Various modifications have been made, especially to collect condensable vapors as in the PHS Method for incinerator testing. Obviously, these different methods will give substantially different results depending on the temperature of filtration to collect samples, and on other variations such as whether or not condensable vapors are also collected and measured.

With some variations in mechanical equipment and procedures, all of these methods are similar in nature. First, a velocity traverse is made with a pitot tube to determine velocity distribution across the duct or stack. Isokinetic sampling is then performed, by controlling the sampling rate so that the linear velocity of the gas stream entering the sampling probe is equal to the linear velocity of the stack gases at that point; this avoids centrifugal effects which would result in samples not representative of the flue gas stream. Particles are collected with an alundum thimble, cyclone collector, filter, or some combination of these. Water is condensed and measured, and other condensable vapors may also be collected for measurement. Simultaneous velocity measurement and sample collection is also possible, using a probe which is equipped with both a pitot tube and a sampling inlet. After collection, samples are dried and weighed, and further laboratory work may be conducted to determine particle size distribution, chemical composition, or other necessary data.

When attempts were made to apply some of these emission standards to process emissions, difficulties arose because of great variations in the volume of gas emitted along with the particulate matter. In some jurisdictions, units of measurement such as weight per unit volume were retained despite these difficulties, but in others the so-called process weight principle has been used. This concept was originally developed in Los Angeles County to apply to the foundry industry. It allows for consideration of the fact that a small foundry cannot do as good a job of controlling emissions, on a percentage basis, as a large foundry. Since its original adoption, the same table with the same numbers has been copied in many other jurisdictions and applied indiscriminately to any and all types of processes. While a detailed study of this matter apparently has never been made, it would appear likely that the use of the same table for different types of industrial operations would impose much more severe restrictions on some industries than on others.

Sulfur compounds have been regulated in a number of jurisdictions and the present regulations seem to have been based in part on a percentage reduction believed necessary to achieve certain ambient air quality goals, and in part on limitations of the available technology for process applications. An example of the first type is the limitation of sulfur in fuel, which serves to reduce emissions of sulfur dioxide though these limits do not constitute "emission standards" in the usual way. The measurement of sulfur in coal and fuel oil has been well known with adequate standard methods for a number of years, and no significant problems of measurement have arisen. For process applications, however, most of the emission standards now in use depend on either a maximum concentration in the stack as measured by stack sampling, or on a maximum concentration in the ambient atmosphere surrounding the plant as measured by conventional ambient air measurement methods. For many years, stack gas concentrations from process sources have been limited to 2000 ppm, with a recent trend in some jurisdictions to reduce this to 500 ppm. This concept was originally developed for application to sulfuric acid manufacturing and has been applied to other process operations involving sulfur dioxide. Most regulations specify one or more of the stack sampling methods contained in PHS Publication 999-AP-13, or their equivalent. These are essentially acid-base titration methods.

Turning now to the more unique emission standards, special problems in certain localities have led to the development of new emission standards by the responsible agencies. Since cities in California led in the development of photochemical smog, it was only natural that the control districts in Los Angeles County and the San Francisco Bay area have led in the development of source sampling relative to hydrocarbons. Los Angeles County, with some exceptions, has operated primarily on the basis of total hydrocarbons, limiting emissions from storage tanks, loading docks, and other facilities handling large quantities of various hydrocarbon mixtures. The San Francisco Bay area, on the other hand, has followed a slightly different approach which places more emphasis on photochemical reactivity, and therefore measurement of individual hydrocarbons is required. This is not a clear-cut distinction, as shown by the fact that Los Angeles County's Rule 66 relating to solvent vapor is also based on reactivity. However, this partial difference in philosophy has led to differences in methods of measurement as outlined in the applicable publications of these two agencies.

The first method used for source measurements of hydrocarbons was developed by the Los Angeles County Air Pollution Control District. Samples are taken in evacuated glass bulbs and transferred to the gas

cell of an infrared instrument for measurement of total hydrocarbons by infrared absorption at a wave length of 3.4 microns. Results are calculated as ppm hexane, since a major concern there is evaporation of gasoline in storage and handling, and hexane was picked as being representative of the molecular weight range and infrared absorptivity of gasoline vapor.

With the adoption of Rule 66 relating to organic solvents and vapors, a different method was developed for use with the greater variety of organic vapors which had to be measured under that regulation. Samples are still taken in evacuated glass bulbs to measure process emissions, vapors in storage areas, or other source sampling involving organic solvents and vapors. These samples are then passed through a combustion tube in which all organic matter is converted to CO_2 which is then measured with a nondispersive infrared analyzer. While based on a different principle, this method also gives a measure of total organic materials without regard to individual organic compounds present. Other methods have been used for special purposes to evaluate classes of compounds or individual compounds by the Los Angeles County Air Pollution Control District. An example of the first type is the use of the fluorescent indicator analysis (FIA) to measure olefins, aromatics, and saturates in hydrocarbon samples. Gas chromatography has been used to measure individual chemical compounds in various organic mixtures but this has been done primarily for research purposes or to meet unique problems, and methods based on gas chromatography have not been widely adopted for generalized application in connection with emission standards.

As mentioned previously, the Bay Area Air Pollution Control District has emphasized photochemical reactivity in Regulation 3 relating to the control of organic emissions. Therefore, the emission standards are stated in terms of reactive components with special emphasis on olefins and substituted aromatics. The determination of these constituents in gaseous effluents is made by absorbing the olefins and substituted aromatics on silica gel, after which they are removed with an appropriate organic solvent and determined by gas chromatography. A similar chromatographic procedure is used for other samples to determine compliance with the various portions of Regulation 3. For solvents and other organic liquids, olefins and substituted aromatics are determined by a sulfonation procedure which is a modification of ASTM Method D-1019-62. For source sampling, however, gas chromatography is the method most frequently used. Another interesting variation is a provision for using a combustible gas indicator for purposes of conducting preliminary tests. Organic gases of less than the allowable limit of 50 ppm (as hexane) when measured in this way are assumed to be in compliance with the

regulation. Emissions showing more than this amount are suspected of being in violation and additional tests are conducted by gas chromatography or other suitable methods, depending on the type of source in question.

A limited number of other process emissions have been covered by emission regulations where specific problems are known to occur. For example, Florida sets a limit for fluoride emissions based on the weight of phosphate (P_2O_5) processed, in order to limit the emission of fluorides by fertilizer manufacturing operations. Texas sets a fluoride limit which is calculated based on meteorological dispersion equations starting with maximum downwind levels off the plant site thought to be acceptable. Very strict limits on beryllium have been adopted in a number of states, based primarily on a comprehensive study originally initiated because of specific problems near beryllium processing operations in Pennsylvania. Some limits have been established on lead and other metals, based at least in large part on previous work done by industrial hygienists to protect industrial workers from toxic metals.

"Fugitive dust" may constitute the most important category of pollutant that is covered in only a very few jurisdictions. Most of the various emission standards are based on measurements which must be made in a stack or duct prior to emission to the atmosphere. The first exception to this principle was the use in California of atmospheric monitoring instruments around industrial plants to measure sulfur dioxide, which was originally introduced as a further check on the stack emission limit of 2000 ppm which was determined by stack sampling. This principle has been further extended by Pennsylvania and Texas in order to permit quantitative measurements of fugitive dust, which is defined as dust which is not emitted through a stack or duct and therefore cannot be measured by conventional stack sampling methods. Examples here might be dust from metallurgical operations which drifts out the side of a building, dust raised by vehicle traffic either on a plant site or on streets and freeways throughout the community, dust blown from an open conveyor or storage pile, dust arising from construction activities, and many others. Regulations in these two states provide for measuring fugitive dust by making ambient air measurements downwind from the suspected source, using a conventional high-volume sampler. Another sampler located upwind or in another suitable location to measure community background levels is also used, with the difference between the two results being the contribution of the source in question to the ambient air levels. Because of variations in background between upwind and downwind locations, margins of error in such measurements may be significant and therefore this

method cannot be used to measure emissions which are relatively small. However, gross sources of emissions sometimes give short-term readings of many hundred or several thousand micrograms per cubic meter, in which case the contribution of the source is much greater than the limits of accuracy of measurement, and this method can be used. This type of measurement has been very useful in making easier the control of severe dust nuisances resulting from fugitive dust emissions.

IV. PRESENT USE OF STANDARD METHODS

Most of the emission standards outlined previously contain some specification of a method of measurement or provide for such specification by an air pollution control agency or other governmental entity. In many cases legal regulations will not specify a method but will state that measurements are to be made by methods acceptable to the commissioner of health, the air pollution control officer, or other official. Frequently, printed methods are provided either as a part of the regulation or as a supplement prepared by the agency itself. Some of these give specific directions for conducting source testing, while others contain background information and/or literature references, and leave the specific choice of methods and techniques to the investigator.

One of the most complete and widely used of these publications is the Source Testing Manual published by the Los Angeles County Air Pollution Control District. In the San Francisco Bay area, appendices are provided for each regulation which outline details of methods of source measurement. These publications might not be considered "standard methods" in the usual sense of the word in that they are more guidelines than standards and leave some discretion to the judgment of the person making such measurements. This may be more desirable in the case of source measurements than ambient air measurements, and such judgment may always be required to allow the investigator to compensate for the great differences in temperature, flow conditions, humidity, and other variables which affect the results.

Historically, the methods for source sampling which have been quoted most often in emission standards are the Power Test Codes published by the American Society of Mechanical Engineers. Some effort at standardization has also been made by ASTM, APCA, and other professional groups.

Within the past few months, the necessity to develop implementation plans under the provisions of the federal Air Quality Act of 1967 has forced many air pollution control agencies to take a closer look at emission standards and at methods of source measurement. Much more activity along this line can be expected on the part of most, if not all, air pollution control agencies. The requirements of the 1970 amendments to the federal Clean Air Act have also focused more attention on the development of emission standards and source measurement methods.

V. CURRENT EFFORTS AT STANDARDIZATION

In addition to the efforts of various governmental agencies to develop emission standards and the concurrent necessity for specifying methods of source measurement, attempts at standardization have been and are being pursued by various scientific groups. The longest "track record" is that of the American Society of Mechanical Engineers which published the first version of the well known Power Test Codes in 1927.

At present, the most concerted activity is being conducted by the American Society for Testing and Materials. Committee D-22 of that organization is working in the field of standard methods for measurement of the atmosphere, and Subcommittee 06 of that committee is devoted to methods for source sampling. The following methods have been adopted or are under consideration by Committee D-22:

Particulate Matter. One method, D-2928-71 "Sampling Stacks for Particulate Matter", has been published as a tentative standard. It is similar to the ASME Power Test Code method except for some technical details regarding sample collection.

Black Smoke. The subcommittee has developed a method to evaluate black smoke by the conventional Ringelmann method, and approval by the full committee is expected within a few months.

Equivalent Opacity. Work is underway by the subcommittee to develop standard methods for equivalent opacity, following the regulations in use in many jurisdictions. Preliminary indications are that subcommittee members believe that severe limitations on the use of this concept will be necessary because of possible sources of error.

Instrumental Methods for Particulates. Subcommittee 06 is evaluating the need for a separate method covering instrumental methods such as the smokescope, transmissometer, etc. Such methods might cover black smoke, emissions other than black as indicated by equivalent opacity, or both.

Sulfur Compounds. Methods are being developed by the subcommittee for sulfur dioxide and sulfur trioxide from fossil fuel combustion sources. These likely will be based on previously published methods such as the so-called Shell method and Monsanto method (PHS Publication 999-AP-13).

General Considerations. Work is being planned by Subcommittee 06 to develop standard methods applicable to most types of sources, covering such items as the measurement of velocity and volume by methods other than pitot tube, possible changes in the pitot tube method specified in D-2928-71, and other general considerations in sample collection. Additional methods for source measurement of gaseous contaminants are also under consideration.

A major activity in the standardization of atmospheric measurement methods is being conducted by the Intersociety Committee,* but this organization has not yet begun work on source sampling methods. There has been some discussion in the Intersociety Committee of the need for source sampling methods, and some effort in that direction may be made in the near future. However, it is the opinion of various persons in the Intersociety Committee that some of the subcommittees would have to be restructured to bring in the proper knowledge and capability to attack the problems of standardization of source measurement methods. No specific plans of this nature have yet been developed.

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* The Intersociety Committee is a cooperative group consisting of representatives of eight scientific and engineering societies:

Air Pollution Control Association
American Chemical Society
American Conference of Governmental Industrial Hygienists
American Industrial Hygiene Association
American Public Health Association
American Society for Testing and Materials
American Society of Mechanical Engineers
Association of Official Analytical Chemists

VI. FUTURE NEEDS

The previous discussion has served to point up the obvious: There is a great need for a much more concerted effort to develop and standardize methods for source measurement. To many who have been involved in the air pollution control field for many years, this realization is long overdue. Nevertheless, this need is now widely recognized, and a considerable emphasis in this area can be expected in the immediate future. Much of this emphasis will come from air pollution control agencies who are just beginning to realize the implications of the federal legislation which requires emission standards as portions of overall implementation plans. Many industrial pollution control people are now reaching the same realization as they have interpreted for them the implications of the same federal legislation by air pollution control agencies and by the companies' own legal counsel.

The major difference in the overall status of source sampling methods as compared to ambient air methods is the greater need for development work in the source measurement area, which follows from the greater variety of conditions likely to be encountered. These variations, as mentioned previously, may always require that a standard method leave a greater amount of leeway for the individual judgment of the investigator, and the degree of standardization probably can never be as complete as in the case of ambient air measurement. In other words, setting up and running a high-volume sampler in Cincinnati involves essentially the same problems that are encountered in setting up and operating a high-volume sampler in Dallas. In source sampling, however, every industry is different, and even individual plants within the same industry will show a considerable degree of variation in operating conditions which in turn influence the problems encountered in source measurement. This may mean that a more rigorous control over the skill and experience of the investigator may be required in source measurements than will be the case in ambient air measurements. If standard methods can be developed to the point where practically all details are specified, then much of the work can be performed by technicians and others with a relatively low level of professional skill. While this has not yet been accomplished in ambient air measurements with any assurance of quality, the likelihood of accomplishing this appears to be even less in considering source measurements.

The need for collaborative testing as a part of the process of standardization is just as great in the development of methods for source measurement. In fact, in view of the more restrictive legal requirements, it may be even greater. However, many practical difficulties

can be anticipated in attempting to conduct multilaboratory collaborative tests of source sampling methods. For any method involving particulate contaminants, the generation of a test atmosphere for purposes of laboratory evaluation will be extremely difficult if not impossible. This means that collaborative testing in some cases will probably have to be performed by bringing a number of collaborators to the same point so that all can sample the same source. For the usual type of stack sampling operation, however, space on sampling platforms will be limited so that only one or two groups can work at any one time and therefore changes in operating conditions between different sampling periods may introduce serious sources of error. Even if these problems can be resolved to any reasonable degree, obtaining test results with a large number of collaborators and/or a large number of samples will be much more difficult than is usually the case in the collaborative testing of ambient air methods. Obtaining a sufficient number of samples to insure statistical validity may be very difficult or impossible.

In developing source sampling methods, there is a great need to shorten the time required to collect and analyze samples. Since source sampling is done to meet immediate needs to a greater extent than ambient air measurement, the several days' time lag inherent in the conventional particulate sampling methods is a severe limitation on the use of such methods. This also raises the question of the availability and suitability of continuous instruments for stack monitoring purposes. Several companies are now developing and introducing new stack monitoring instruments to measure a variety of contaminants, and continued activity in this field can be anticipated.

As with ambient air measurements, manual reference methods can be used as a means of checking on the calibration of continuous analytical instruments. Here again, however, the comparability of the reference method and of the measurement obtained by a continuous instrument must be established by detailed development work before routine use of a stack monitoring instrument is feasible. Thus, in the development and standardization of source sampling methods, a division might be made similar to the division already being observed in ambient air sampling methods. That is, reference methods should be developed to provide a standard basis for measurement, and these in turn should then be used as a means of checking the suitability of various stack monitoring instruments for continuous process use. Once this comparability has been demonstrated, stack monitors can then be used for routine operation and checks by a reference method can be limited to a rather infrequent schedule.

The use of stack monitoring instruments raises other questions in connection with the legal aspects of developing and applying emission standards. Nearly all of the standards now in effect require the use of manual sampling and analytical methods which involve a considerable time lag in obtaining results. There is a need for new concepts in the legal field so that regulations and emission standards can be written directly in terms of measurements made with continuous instruments. One example of this concept has already been developed in the state of Texas, where an instrumental method has been written into a legal emission standard as a substitute for the visual estimation of equivalent opacity. This eliminates problems inherent in visual observation, and legal compliance with this regulation can be demonstrated only on the basis of an instrumental measurement without the necessity to demonstrate comparability between the instrumental method and a reference method. In this particular instance, the instrumental method is more accurate and reliable than the conventional visual method, and therefore the question of comparability is not applicable. However, the further development of legal concepts which would permit the use of emission standards tied directly to instrumental readings would be of considerable benefit in eliminating time lag, uncertainty, and confusion in the operation of various stationary sources subject to emission standards.

One other question which seems to have been partially overlooked in the past is the comparability of ambient air measurements and source measurements. No specific recommendations can be made to overcome this limitation except the obvious one that further work done to develop methods for both ambient air measurements and source measurements should include some consideration of this problem. In the work which is now in progress to evaluate methods for ambient air measurements prior to collaborative testing and adoption of standards, some consideration should be given where possible to the nature of the source sampling methods which are available for the same contaminant. One example here is the effect of particle size in measuring total particulates. The conventional high-volume method for particulates includes very few particles larger than 50 microns, whereas the conventional method for source sampling is supposed to obtain a representative sample of the material in the stack irrespective of particle size. If a large portion of the emission consists of large particles, it is obvious that many of these particles will fall to the ground within a short distance of the stack, partly on the plant property. In this special situation, a stack measurement could not relate directly to an ambient air measurement in the community using a high-volume sampler.

Another problem may occur with organic matter which would be measured as a constituent of particulate matter by some stack sampling methods or would be recovered in a condensate trap in sampling. In actual fact, at least a portion of such organic matter probably would be diluted in the atmosphere following emission and would remain in the vapor phase. Thus, a stack measurement might reflect the presence of organic matter but give an erroneous indication of the physical state of such constituents after emission to the atmosphere. Problems of this nature affect a legal definition of particulate matter as well as the procedures used in sampling with respect to temperature, flow rate, condensate traps, etc. Similar examples of this lack of comparability might be shown for sulfur dioxide, hydrogen chloride, hydrocarbons, and many other contaminants subject to control through the use of emission standards and source sampling methods.

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Bay Area Air Pollution Control District (San Francisco Bay area)

Allegheny County, Pennsylvania

County of San Bernardino, California

Metropolitan Dade County, Florida

County of Sarasota, Florida

City of Chicago, Illinois

City of Cleveland, Ohio

City of Poughkeepsie, N. Y.

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